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V. *Experiments on Hepatic Air.*By Richard Kirwan, *Esq. F. R. S.*

Read December 22, 1785.

HEPATIC Air is that species of permanently elastic fluid which is obtained from combinations of sulphur with various substances, as alkalis, earths, metals, &c. It possesses many peculiar and distinct properties; among which the most obvious are, a disagreeable characteristic smell emitted by no other known substance; inflammability, when mixed with a certain proportion of respirable or nitrous air; miscibility with water, to a certain degree; and a power of discolouring metals, particularly silver and mercury. These properties were first discovered by that incomparable analyst M. SCHEELE.

This air acts an important part in the œconomy of nature. It is frequently found in coal-pits; and the truly excellent and ever to be regretted M. BERGMAN has shewn it to be the principle on which the sulphureous properties of many mineral waters depend, and thus happily terminated the numerous disputes which the obscurity of that subject had occasioned. There is also great reason to think, that it is the peculiar product of the putrefaction of many, if not all, animal substances. Rotten eggs and corrupt water are known to emit the smell peculiar to this species of air, and also to discolour metallic substances

stances in the same manner. M. VIELLARD has lately discovered several other indications of this air in putrefied blood.

Yet, deserving as this substance appears to be of a thorough investigation, it has as yet been very little attended to. The experiments of M. BERGMAN have not been sufficiently numerous, and thereby led him into some mistakes. Dr. PRIESTLEY has intirely overlooked it. The researches of the ingenious M. SENNEBIER, of Geneva, have indeed been very extensive; but as, for particular reasons, he operated on this air over water (by which it is in great measure absorbed) instead of quicksilver, his conclusions appear in many respects objectionable, as will be seen in the sequel. The experiments I have now the honour of laying before the Society were all made over quicksilver, and several times repeated.

SECTION I.

Of the Substances that yield Hepatic Air, and the means of obtaining it.

It is well known, that *saline* liver of sulphur is formed, in the dry way, of a mixture of equal parts of vegetable or mineral alkali and flowers of sulphur, melted together by a moderate heat, in a covered crucible. I examined the circumstances of its formation, and observed, that when this mixture was slightly heated, it emitted a bluish smoke, which gradually grew whiter as the heat was increased, and at last, when the mixture was perfectly melted, and the bottom of the crucible slightly red, became perfectly white and inflammable. To examine the nature of this smoke, I made a pretty pure fixed alkali, by deflagrating equal parts of cream of tartar and nitre.

nitre in a red-hot crucible in the usual way ; and mixing this salt perfectly dry with flowers of sulphur in much smaller quantity, as I believe (for I did not weigh the salt, least it should, during the weighing, attract moisture) I gradually heated the mixture in a small coated glass retort, and received the air proceeding from it over quicksilver.

The first portion of air that passed with a very gentle heat was that of the retort itself, slightly phlogisticated. It amounted to 1,5 cubic inches, and with Dr. PRIESTLEY's nitrous test (that is, an equal measure of nitrous air) its goodness was 1,29. It contained no fixed air.

The second portion of air obtained by increasing the heat amounted to about 18 cubic inches. It was of a reddish colour, and seemed a mixture of nitrous and common air. It slightly acted on the mercury.

The third portion consisted of 20 cubic inches, and appeared to be of the same kind as the last, but mixed with a little fixed air.

This was succeeded by 64 cubic inches of almost perfectly pure fixed air ; and the bottom of the retort being now red, some sulphur sublimed in its neck. When all was cold, liver of sulphur was found in the bulb of the retort.

Hence we see, that the blue smoke consists chiefly of fixed air, and the white or yellow smoke of sulphur sublimed ; and that no hepatic air is thus formed ; nor vitriolic air, unless the retort be so large as to contain a sufficiency of common air to admit the combustion of part of the sulphur.

2dly, That the ærial or any other acid, combined with the alkali, must be expelled before the alkali will combine with the sulphur. Liver of sulphur exercises a strong solving power on the earth of crucibles, and readily pierces through them.

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The above experiment seems to shew that liver of sulphur will not yield hepatic air without the addition of an acid; and I believe this to be true when the experiment is made in the dry way, and nearly so in the moist way; for having added 200 grains of sulphur to a concentrated solution of strong caustic vegetable alkali, by a strong and long-continued heat I obtained only 1 cubic inch of hepatic air; yet it is well known, that a strong solution of liver of sulphur constantly emits an hepatic smell, even in the temperature of the atmosphere; and the substance so emitted contains so much hepatic air as to discolour silver and lead, and even their solutions; which shews, that an incomparably small quantity of this air is capable of producing this effect. To discover whether this extrication of hepatic air might be caused by the deposition of fixed air from the atmosphere, I threw some pulverised calcareous hepar into aerated water, and by the application of heat endeavoured to obtain hepatic air, but in vain: and, indeed, the very circumstance that the hepatic smell, and its effects, are always strongest the first instant that a bottle of the hepatic solution is opened, seems to indicate that fixed air is no way concerned in its production.

The best liver of sulphur is made of equal parts of salt of tartar and sulphur; but as about one-fifth of the salt of tartar consists of air which escapes during the operation, it seems, that the proportion of sulphur predominates in the resulting compound; yet as some of the sulphur also sublimes and burns, it is not easy to fix the exact proportion. 100 grains of the best, that is, the reddest liver of sulphur, afford, with dilute marine acid, about 40 cubic inches of hepatic air, in the temperature of 60°: a quantity equivalent to about 13 grains of sulphur, as will be seen in the sequel.

The *marine* acid is the best adapted to the production of hepatic air. If the concentrated *nitrous* acid be used, it will afford nitrous air; but having diluted some nitrous acid, whose specific gravity was 1,347, with 20 times its bulk of water, I obtained, with the assistance of heat, as pure hepatic air as with any other acid.

The concentrated *vitriolic* acid, poured on liver of sulphur, affords but little hepatic air without the assistance of heat, though it instantly decomposes the liver of sulphur; and it is partly for this reason that the proportion of air is so small; for it is during the *gradual* decomposition of sulphureous compounds that hepatic air is produced.

Distilled *vinegar* extricates this air in the temperature of the atmosphere; but it is not pure, its peculiar smell being mixed with that of vinegar.

The *acid of sugar* also produced some quantity of this air in the temperature of 59°.

20 grains of *sedative salt*, or acid (as it should more properly be called) dissolved in an ounce of water, being poured on liver of sulphur, afforded hepatic air only when in a boiling heat, or nearly so.

Neither the *aërial* nor *arsenical* acids produce any.

Liver of sulphur is soluble not only in water but in spirit of wine, and in caustic volatile alkalies; and the colour of both solutions is red. Sulphur is precipitable from the former by the addition of water or of an acid, but from the latter only by an acid.

Having made some liver of sulphur, in which the proportion of sulphur much exceeded that of the alkali, I poured on part of it some oil of vitriol, whose specific gravity was 1,863: by this means I obtained hepatic air, so loaded with

with sulphur, that it deposited some in the tube through which it was transmitted, and on the upper part of the glass receiver. This air I transferred to another receiver; but though it was then perfectly clear and transparent, and amounted to 6 cubic inches, yet the next morning the inside of the glass was thickly lined with sulphur, and the air reduced to 1 cubic inch, which was pure vitriolic air. Hence it appears, first, that a species of elastic fluid may exist in a state intermediate between the aërial and the vaporous, which is not permanently elastic like air, nor immediately condensed by cold like vapour, but which, by the gradual loss of its specific heat, may be reduced to a concrete form. 2dly, That so large a quantity of sulphur may be combined with vitriolic air, as to enable it to exhibit the properties of hepatic air, for some time at least. A mixture of three parts pulverised quick-lime and one part sulphur, heated to whiteness in a covered crucible for one hour, became of a stony hardness, and being treated with marine acid, afforded hepatic air. If a piece of this stone be heated in pure water it becomes bluish, and hence the origin of the blue marles generally found near hot sulphurated waters.

A calcareous hepar may also be formed in the moist way, as is well known.

Magnesia free from fixed air, heated in the same manner with sulphur, afforded no hepatic air when an acid was poured on it.

I also procured this air from a mixture of three parts *filings of iron* and one of sulphur, melted together, and treated with marine acid. It is remarkable, that this sulphurated iron, dissolved in marine acid, affords scarce any inflammable, but mostly hepatic air.

A mixture of equal parts filings of iron and sulphur, made into a paste with water, after heating and becoming black, afforded hepatic air when an acid was poured on it; but this hepatic air was mixed with inflammable air, which probably proceeded from the uncombined iron. After a few days, this paste lost its power of producing hepatic air.

M. BERGMAN has remarked, that combinations of sulphur with some other metals yield hepatic air.

I attempted extracting air from a mixture of oil of olives with caustic vegetable alkali. It immediately whitened, and on applying heat effervesced so violently as to pass over into the receiver: nor had I better success on adding an acid, as I might well foresee. The event was different when on a few grains of sulphur I poured some of the oil, and heated them in a phial with a bent tube; for as soon as the sulphur melted, the oil began to act on it, grew red, and emitted hepatic air, similar to that produced by other processes.

I also obtained this air in great plenty from a mixture of equal parts sulphur and *pulverised charcoal*, out of which its adventitious air had been as much as possible expelled by keeping it a long time heated to redness, in a crucible on which a cover was luted, with a small perforation to permit the air to escape. This air was inflammable, as appeared by holding a lighted candle before it during its emission; yet it is hardly possible to free charcoal wholly from foreign air, for it soon re-attracts it when exposed to the atmosphere.

This last mixture, when distilled, affording a large quantity of hepatic and some inflammable air, without the addition of any acid, I imagined, that as the retort was only half full, it might contain a sufficiency of atmospheric air to admit the combustion of part of the sulphur, and thus furnish the neces-

sary acid; but when I filled the retort with air phlogisticated by the nitrous test unto 1,8, and in this air distilled the above mixture, the result was exactly the same as when the retort was filled with atmospheric air.

Six grains of *pyrophorus*, made of alum and sugar, effervesced with marine acid, and afforded 2,5 cubic inches of hepatic air. This pyrophorus had been made six years before, and was kept in a tube hermetically sealed, and for many summers exposed to the strongest light of the sun. It was so combustible, that some grains of it took fire while it was introduced into the phial out of which the hepatic air was expelled.

A mixture of two parts *white sugar* (previously melted in order to free it from water) with one part sulphur, when heated to about 600 or 700 degrees, gave out hepatic air very rapidly. This air had a smell much resembling that of onions; it contained no fixed air, nor saccharine, or other acid. But sugar and sulphur, melted together, gave out no hepatic air when treated with acids. Water, spirit of wine, and marine acid, decompose this mixture, dissolving the sugar, and leaving the sulphur.

A mixture of sulphur and *plumbago* afforded me no hepatic air.

I then tried whether sulphur could combine with elastic fluids, and the results were as follows.

12 grains of sulphur, heated in a retort, filled with metallic *inflammable* air, afforded no hepatic air; though when the retort was cold, and for some time exposed to the air, it smelled of hepatic air. It is true, the heat I applied might be insufficient; for the inflammable air passing over with a slight heat, the mercury ascended so high into the neck of the receiver, that, fearing the rupture of the retort, I was obliged to interrupt the
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the operation. I had no better success when the sulphur, previous to its distillation, had been moistened with marine acid.

Again, I exposed 18 grains of liver of sulphur to six cubic inches of *fixed air*, thermometer 70°, for four days. The liver of sulphur was somewhat whitened on the surface; the air had not an hepatic smell, but rather that of bread. It was not converted into phlogisticated air, but seemed to have taken up some sulphur, which lime-water separated. It was not in *the least diminished*, and therefore seems to have received an addition of hepatic air, or rather of sulphur.

I also exposed a quantity of *sulphureo-martial paste* to fixed air, for five days. The fixed air was not diminished, but received a slight accession of inflammable air. The paste itself, taken out of this air, and exposed to the atmosphere, heated strongly.

Lastly, I exposed 3 grains of sulphur to about 12 cubic inches of *marine air*. It was not diminished in four days; nor was the sulphur sensibly. On adding one cubic inch of water to this air, it was absorbed all to one inch, and this had an hepatic smell; so that neither was the sulphur decomposed, nor the marine acid converted into inflammable air. The water had also an hepatic smell, and evidently contained sulphur; for it precipitated the solution of silver *brown* mixed with white, and the nitrous solution of copper *reddish brown*, and when vegetable-fixed alkali was dropped into it, let fall a white precipitate, namely, the sulphur.

SECTION II.

Of the general Characters of Hepatic Air.

I found the absolute weight of this air by weighing it in a glass bottle, previously exhausted by Mr. HURTER's new improved air-pump, whose effect is so considerable as to leave in general only $\frac{1}{1000}$ and frequently but $\frac{1}{10000}$ part of unexhausted air. This bottle contained 116 cubic inches nearly; and this quantity of hepatic air weighed 38,58 grains, the thermometer being then $67^{\circ},5$, the barometer 29,94, and M. SAUSSURE's hygrometer 84° , the weight of 116 cubic inches of atmospheric air being at the same time 34,87 grains; hence a cubic foot of hepatic air weighs, in these circumstances, 574,7089 grains, and 100 cubic inches of it weigh about 33 grains; and its weight, relatively to that of common air, is as 10000 to 9038 *. This hepatic air was extracted from artificial pyrites by marine acid.

The inflammability of this air has been already mentioned. It never detonates with common air; nor can it be fired, in a narrow-mouthed vessel, unless mixed with a considerable proportion of this air. M. SCHEELE found it to inflame when mixed with two-thirds of this air. According to M. SENNEBIER

* Hence the weight which I have assigned to common air in my first paper, after M. FONTANA, is evidently erroneous; and, indeed, by that determination common air would not be even 700 times lighter than water, in the temperature of 55° , and the barometer 29,5, which contradicts all barometrical and aerostatic experiments: and I cannot omit mentioning the very near agreement of the weight of common air here found with that resulting from the calculation of Sir GEORGE SHUCKBURGH, it is so great as to differ only by 2 grains in a cubic foot.

it cannot be fired by the electric spark, even when mixed with any proportion of respirable air. I found a mixture of one part of hepatic air and 1,5 of common air to burn blue, without flashing or detonating. During the combustion sulphur is constantly deposited, and a smell of vitriolic air is perceived. A mixture of half hepatic and half nitrous air burns with a bluish, green, and yellow lambent flame; sulphur is also deposited, and in proportion as this is formed, a candle dipped in this air burns more weakly, and is at last extinguished. A mixture of two parts nitrous and one of hepatic air partially burns, with a green flame, and a candle is extinguished in the residuum, which then reddens on coming in contact with atmospheric air. I made a mixture of one part nitrous and one part hepatic air, and to this admitted one part also of common air; the instant the common air was introduced, sulphur was precipitated, and the three measures occupied the space of 2,4 measures; this burned on the surface with a wide greenish flame, but the candle was extinguished when sunk deeper.

A mixture of four parts common air and one part hepatic burned blue and rapidly; but a mixture of one part dephlogisticated and one part hepatic, which had stood eight days, went off with a report as loud as that of a pistol, and so instantaneously that the colour of the flame could scarce be discerned.

Every species of hepatic air turns the *tincture of litmus* red. M. BERGMAN seems to think, that, if this air were washed, it would not produce this effect; yet, when I had passed two measures of it through one of water, or when I had boiled it out of water impregnated with it, or even when I passed that which had already reddened litmus, into a fresh quantity of litmus, it still preserved the same property, which I therefore consider as essential to it.

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With respect to *solubility in water*, hepatic airs extracted from different materials differ considerably. In the temperature of 66°, water dissolves, by slight agitation, two-thirds of its bulk of alkaline or calcareous hepatic air, extracted by marine acid; three-fourths of its bulk of martial hepatic air, extracted by the same acid; eight-tenths of that extracted by means of the concentrated vitriolic acid, or the dilute nitrous or saccharine acids in the temperature of 60°; seven-tenths of sedative hepatic air; nine-tenths of acetous hepatic air, and of that afforded by oil of olives; and its own bulk of that produced from a mixture of sugar and sulphur. In general, I imagined that which required most heat for its production to be most soluble: though in some instances, particularly that of acetous hepatic air, that circumstance does not take place.

But the most remarkable phænomenon attending the union of hepatic air with water is, that it is not permanent. Even water, out of which its own air had been boiled, in a few days after saturation with hepatic air grows turbid, and in a few weeks deposits most of it in the form of sulphur, though the bottle be ever so well stopped, or stand inverted in water or mercury. Yet water no way decomposes hepatic air by absorbing it; for the part left unabsorbed by a quantity of water is absorbable by a larger quantity of water, and burns like other hepatic air. Heat does not expel this air from water, until carried to the degree of ebullition.

No species of hepatic air, which I have examined, precipitates lime from *lime-water*, except the carbonaceous; and even this scarcely produces a sensible precipitation, unless a large quantity of it be made to pass through a small quantity of lime-water.

The solution of *acetous baro-selenite*, (that is, ponderous earth dissolved in distilled vinegar) is rendered brown and turbid by this air, but that of *marine baro-selenite* is not altered; nor are the solutions of other earths. Metallic solutions are affected by it in the same manner as by hepatic water, of which I shall treat in the fifth section.

But of all the tests of hepatic air, the most delicate and sensible is the *solution of silver in the nitrous acid*. This, according as the nitrous acid is more or less saturated with silver, becomes black, brown, or reddish brown, by contact with hepatic air however mixed with any other air or substance. When the acid is not saturated, or is in large proportion, the brown or black precipitate, which is nothing but fulphurated silver, is re-dissolved.

It should also be remarked, that all hepatic air is somewhat diminished by long standing on mercury, whose surface is then blackened by it. This is particularly the case of carbonaceous hepatic air, which certainly carries over and volatilizes part of the charcoal from which it is extracted, especially that portion of air which comes over in the greatest heat; this it deposits on the addition of water.

SECTION III.

Of the Action of Hepatic and other Aerial Fluids on each other.

Six cubic inches of common and six of hepatic air being mixed with each other, and standing over mercury for eight days, were not in the least altered in their dimensions or otherwise; though a diminution of a $\frac{1}{120}$ th part might be perceived. The mercury was slightly blackened. The event was the same
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when three measures of common and one of hepatic air were used. Water took up the hepatic air. No fixed air was found.

Five measures of hepatic, and five of *dephlogisticated* air so pure that one measure of it and two of nitrous air made only three-tenths of a measure, remained unaltered for eight days, the mercury only being blackened. No fixed air was produced, nor the dephlogisticated air phlogisticated. When the mixture was fired, it went off all at once with a loud report.

Four measures of phlogisticated and four of hepatic air remained undiminished for sixteen days: water then took up the hepatic, and left the phlogisticated air.

Four measures of *inflammable* and four of hepatic air remained unaltered for six days.

Two measures of hepatic and two of *marine acid* air suffered no diminution in three days. The mercury on which they stood was not blackened. Water took up both, and precipitated the solution of silver black.

The same quantity of hepatic and *fixed* air remained four days without any sensible diminution. Four measures of water absorbed the greater part of both, had an hepatic smell, precipitated lime from its solution, and also silver, as usual. The residuum extinguished a candle.

But *vitriolic*, *nitrous*, and *alkaline* airs had very remarkable effects on hepatic air.

Two measures of hepatic being introduced to two of *vitriolic* air, a whitish yellow deposition immediately covered both the top and sides of the jar, and both airs were, without any agitation, reduced to little more than one measure; but the opacity of the incrustated glass prevented my then ascertaining the diminution with precision. Hence I repeated this experiment more at large, in the following manner. To five measures of vitriolic air (each measure containing a cubic inch) I added one

of hepatic air. In less than a minute, without any agitation, the sides of the glass were covered with a whitish scum, which seemed moist, and a diminution took place of more than one measure. In four hours after, I introduced a second measure of hepatic air, which was followed by a similar diminution and deposit. The next day I added three more measures of this last, at the interval of four hours between each; and still finding a considerable diminution after each, I the following day added another measure; the diminution produced by this last appeared to me not to exceed one measure. I then poured off the residuary air into another jar, and found it not to exceed three measures; so that here eleven measures, namely, five of vitriolic and six of hepatic air, were reduced to three. Into one measure of this residuary air I introduced a lighted candle: it was immediately quenched. To the two remaining measures I added one measure of water: by agitation it took up four-tenths of its bulk. To part of the remainder I added nitrous air, which had no effect upon it. Another part of it extinguished a candle. It had not a vitriolic smell.

The water which had taken up four-tenths of its bulk of this air did not precipitate lime; nor did it affect acetous baro-selenite in less than a quarter of an hour, and then produced a very slight cloud. It sensibly reddened litmus, and precipitated the solution of silver white; and hence it appears to have taken up a very minute portion of vitriolic acid. And what was not taken up by water seems to have been mere phlogisticated air.

I afterwards washed the sulphur, which coated the jar, with distilled water. This water slightly reddened litmus, precipitated not only the acetous, but also marine baro-selenite copiously, as well as marine and nitrous selenite; also the nitrous solutions of silver, lead, and mercury, all white. It even

precipitated lime from lime-water, forming a cloud in it, which neither the fixed nor volatile acid of vitriol can produce. Hence this water contained nothing hepatic; but, on the contrary, a considerable proportion of the aërial and vitriolic acids*.

With *nitrous air* I made the following experiments. First, I found that two measures or cubic inches of nitrous and two of hepatic air were little altered when first mixed, even by agitation; but after thirty-six hours both were reduced to nearly one-third of the whole, but something more. Yellow particles of sulphur were deposited both on the mercury, and on the sides of the jar, but the mercury was not blackened. The residuary air had still an hepatic smell, and was somewhat further diminished by water; and in the unabsorbed part a candle burned naturally. The water had all the properties of hepatic water.

Perceiving by this experiment that I had not employed enough of nitrous air to condense the hepatic perfectly, to eight cubic inches of hepatic air I added nine of nitrous air, all at once; a yellowish cloud instantly appeared, a slight white scum was deposited on the sides of the jar, and the whole seemed diminished about two cubic inches, or between one-ninth and one-eighth, the temperature of the room being then 72°. I then laid by the mixture, and in forty-eight hours after, I found the whole reduced to six cubic inches, and the top and sides of the jar covered with a white cake of sulphur, the heat of the room being constantly kept between 60° and 70°. Finding the diminution to reach no further in

* Note, the vitriolic acid air here employed was the purest possible; it was extracted from sulphur distilled with precipitate *per se*.

twenty-four hours more, I examined the residuary air. It exhibited the following appearances.

1°, It had the smell of alkaline air pretty strongly; at least that smell issued from the jar that contained it after the air itself was poured into another jar.

2°, A candle burned in it naturally.

3°, It did not affect tincture of litmus or lime-water, or acetous barytes.

4°, No species of air had any effect on it except the dephlogisticated, with which it produced a slight redness and diminution.

5°, It produced a slight white precipitate in solution of silver.

It is plain, this air is the same as that which Dr. PRIESTLEY calls *dephlogisticated nitrous air*, and which, I think, may more properly be called *deacidified nitrous air*. A further examination of it would lead me too far from the present subject: I shall therefore defer it until another opportunity.

As it appeared to me, from the experiment mentioned in the second section (in which I found sulphur precipitated from a mixture of nitrous and hepatic air, immediately after the admission of common air) that an uncombined acid in the nitrous air was the cause of the precipitation of sulphur; I attempted depriving nitrous air of any loose acid it might contain, before I should mix it with hepatic air.

1st, I made some nitrous air from silver very carefully over boiled and filtered water, and found it to contain an acid, for it strongly reddened tincture of litmus.

2dly, I admitted alkaline air to this nitrous air until it no longer caused any cloud, and then washed out the ammoniacal compound in distilled water; after which I transferred this

purified nitrous air to the mercurial tub. It appeared to lose, by privation of its acid, about one-sixth of its bulk; and it was diminished by common air just in the same manner as unpurified nitrous air is.

Then to 8 cubic inches of this purified nitrous air I admitted all at once 7 cubic inches of hepatic air. No cloud, diminution, or deposit, appeared; but in six hours after (the temperature of the room being all the time at 76°), the whole was reduced to 5 cubic inches; the diminution went no further eighteen hours after. Sulphur, much whiter than in the former experiments, was deposited, and both in this and in the former experiments that part of it which, by the rising of the mercury, was intercepted between it and the jar, was of a yellow and red shining colour, and not black as that deposited on mercury usually is. The residuary air flashed with so much vehemence as to extinguish the candle dipped into it, by the violence of the blast. The flame was exceeding white and vivid; but it did not detonate in the least, but rather resembled dephlogisticated air. The jar out of which it had been transferred had a sharp alkaline smell.

This air was not in the least diminished by nitrous air, even when heated to 150 degrees; which heat I contrived to produce by passing the upper part of the jar that contained this air into another wider jar, furnished with a perforated cork bottom, and filling this with water heated to that degree.

Water poured into the jar in which the sulphur was deposited, produced a bluish white cloud in solution of silver, though insipid to the taste.

Hence it appears to me, that, whatever this air may be, it had been deacidified by hepatic air still more perfectly than
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that in which a candle burns naturally; and that it is by no means dephlogisticated.

Lastly, *Alkaline* and hepatic airs, perfectly pure and mixed in proper proportions, would probably destroy each other completely, though I have not been able to effect this intirely. Six measures of hepatic air from liver of sulphur and 6 of alkaline air immediately throw up a white cloud, leave a whitish scum on the sides of the jar, and are reduced to about 1 measure. On adding water this is reduced to about one-half; and in this I found a candle to burn naturally: but the following experiments, being made with more care, prove that this residuary air was only the common air of the vessels.

To 6 cubic inches of calcareous hepatic air I admitted, all at once, 7 of alkaline air; a white cloud and a little white scum at first appeared; but in a few seconds the whole was reduced to six-sevenths of a cubic inch; and on adding 2 measures of water, only one-ninth of a cubic inch of air remained. This could not be inflamed. The water, thus impregnated, precipitated a solution of silver black. In this experiment great care was taken to have each of the mixed airs as pure as possible, and the alkaline was admitted all at once, instead of by different portions, merely with that view; and it is probable, that, if the due proportion were hit upon, nothing would remain. The scum appears to be almost liquid, and as soon as the jar is emptied of mercury, it breaks out into a white smoke, with an exceeding sharp urinous smell.

Five measures of martial hepatic air were, upon the admission of $5\frac{1}{4}$ of alkaline air, reduced to something more than one measure, and upon the addition of water there remained but half a measure; and this was inflammable, with detonation; the
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inflammable air undoubtedly proceeding from the solution of the iron.

Five cubic inches of saccharine hepatic air, mixed with 5 of alkaline air, were diminished more slowly; for after five minutes there still remained 4,5 cubic inches. I then added another measure of alkaline air: in three hours after there remained but 1,25 cubic inches. In passing this residuum through water it was reduced to about half a cubic inch; and this burned with a blue lambent flame, without leaving a vitriolic smell or any deposit on the glass; so that it clearly was inflammable air from the sugar.

I once imagined I had obtained inflammable air from a mixture of alkaline air with hepatic air drawn from liver of sulphur; but I afterwards found this inflammable air proceeded from a very slight contamination of zinc in the mercury over which my airs had been produced; the alkaline air acted on this zinc, and must have produced the inflammable air; for when I afterwards received and mixed these airs over mercury, perfectly purified, I obtained no more inflammable air.

SECTION IV.

Of the Action of Hepatic Air, and Acid, Alkaline, and Inflammable Liquids, on each other.

One measure of *oil of vitriol*, whose specific gravity was 1,863, absorbed two measures of hepatic air all to one-tenth. The acid was whitened by a copious deposition of sulphur. I also introduced, over mercury, a measure of red *nitrous acid*, whose specific gravity was 1,430, to an equal measure of hepatic air; red

vapours instantly arose, and only one-tenth or one-twelfth of a measure remained in an aerial form; but as the acid acted on the mercury, I was obliged to carry the jar into the water tub, by which means the whole was absorbed: no sulphur was here precipitated.

I repeated this experiment in another manner. Having produced 4,5 measures of hepatic air over mercury, I transferred them to the water tub, and instantly by means of a syphon blew into them one measure of the above concentrated nitrous acid; but though I managed as quickly as possible, the hepatic air was something diminished by contact with the water, before the acid had entered the tube that contained the air. I then stopped the tube with a ground glass stopper, and laid it by for twelve hours; after which interval I found the liquor in the tube white and turbid, and but weakly acid, much water having entered in spite of my endeavours to exclude it. The remaining air slightly detonated on presenting to it a lighted candle, and had an hepatic smell. But as this hepatic air was obtained from sulphureo-martial paste, it does not prove that inflammable air enters into the composition of other hepatic airs, derived from the union of sulphur with substances that do not yield inflammable air.

Finding it so difficult to subject hepatic air to the direct action of the concentrated nitrous acid, I diluted it to that precise degree at which it could not act on mercury without the assistance of heat, and then passed through it an equal bulk of the same hepatic air; the acid was whitened, and eight-tenths of the air absorbed, and the residuum detonated. Repeating the same experiment with hepatic air from liver of sulphur, I found still more of it absorbed by the acid; but the residuum

no longer detonated, but burned with a blue and greenish flame, and sulphur was deposited on the sides of the jar.

Observing this dilute acid to absorb nearly three times its bulk of alkaline hepatic air, I expelled this air from it by heat, but obtained only one-sixth of the air that had been absorbed; and in this a candle burned naturally.

Two measures of alkaline hepatic air, being exposed to one of strong *marine acid*, were absorbed, by slight agitation, all to one-fifth of a measure. A third measure of air being then added, there remained, after some agitation, but half a measure. Sulphur was precipitated as usual; but the mercury over which the acid stood attracted it from the acid; for it was blackened, which did not happen when the former acids were used. The residuum burned just as pure hepatic air.

Distilled vinegar absorbs nearly its own bulk of air, and becomes slightly whitened; but by agitation it may be made to take up about twice its bulk, and then becomes very turbid.

One measure of *caustic vegetable alkali*, whose specific gravity was 1,043, absorbed nearly four measures of alkaline hepatic air. It was at first rendered brown by it; but after some time it grew clear, sulphur was deposited, and the surface of the mercury blackened. This shews that alkalies are not dephlogisticated by silver or other metals, as Mr. BAUME imagined, but only cleared of part of the sulphur, which they commonly contain, it being formed by the tartar vitriolate contained in the plant, and coal, during combustion.

One measure of *caustic volatile alkali*, whose specific gravity was 0,9387, absorbed 18 of hepatic air. If the caustic liquor contained more alkali, it would absorb more hepatic air, as 6 measures of hepatic unite to 7 of alkaline air; and thus the strength of alkaline liquors, and their real contents, may be

determined better than by any other method. Also the smoaking liquor of BOYLE, which is difficultly prepared in the usual way, may easily be formed by placing the volatile alkali in the middle glass of Dr. NOOTH's apparatus for making artificial mineral waters, and decomposing artificial pyrites, or liver of sulphur, in the lower glass, by marine acid.

Oil of olives absorbs nearly its own bulk of this air, and obtains a greenish tinge from it.

But *new milk* scarcely absorbs one-tenth of its bulk of this air, which is very remarkable, and is not in the least coagulated.

Oil of turpentine also absorbs its own bulk of this air, and even more; but then becomes turbid. Water seems also to precipitate this air from it, for when shaken with it a white cloud appears.

Spirit of wine, whose specific gravity was 0,835, absorbed nearly three times its bulk of this air, and became brown. By this means sulphur may be combined with spirit of wine much more easily than by Count LAURAGAI's method, the only hitherto known. Water precipitates the sulphur in part.

Sulphurated spirit of wine does not tinge litmus red; but it precipitates lime-water, as highly rectified spirit of wine singly does. It also precipitates and gives a brown colour to acetous baro-felenite, which spirit of wine alone also does. It turns the solution of silver black and reddish brown. Concentrated vitriolic acid precipitates the sulphur from it, which neither the nitrous nor marine acids can effect.

When hepatic air is mixed with an equal bulk of *vitriolic æther*, the bulk of the air is at first increased; but afterwards half of it is absorbed, and a slight precipitation appears. The smell of the æther is mixed with that of the hepatic air; but on adding

water

water it becomes very offensive, resembling that of putrefying animal substances.

To one measure of hepatic air I added 1,5 of the nitrous solution of silver: the air was immediately, without agitation, reduced to half a measure, and the solution blackened. The remaining air admitted a candle to burn naturally. Hepatic air was also absorbed, but not so readily, nor in such quantity, by the solution of vitriols of iron and silver; that of silver was blackened; that of iron at first became white, but by agitation darker. The residuary air burned blue, as hepatic air usually does.

SECTION V.

Of the Properties of Water saturated with Hepatic Air.

This water turns tincture of litmus red.

It does not affect lime-water.

It does not form a cloud in the solution of marine, though it does in that of acetous baro-felenite.

The solutions of other earths in the mineral acids are not altered by it.

When dropped into a solution of vitriol of iron or marine salt of iron, it produces a white precipitate.

In nitrous salt of copper it causes a brown precipitate, and the liquor is changed from blue to green. The precipitate re-dissolves by agitation. In vitriol of copper it forms a black precipitate.

The solution of tin in aqua regia is precipitated by it of a yellowish white colour; that of gold, black; that of regulus of antimony,

antimony, red and yellow; that of *platina*, red mixed with white.

The solution of *silver* in the nitrous acid, and also that of *lead*, whether in the acetous or nitrous acid, are precipitated black. if the solutions are not perfectly saturated with metal, the precipitates will be brown or reddish brown, and may be redissolved by agitation.

The nitrous solution of *mercury* is precipitated of a yellowish brown; that of sublimated corrosive, yellow mixed with black; but by agitation it becomes white.

The nitrous solution of *bismuth* becomes, by mixture with this water, reddish brown, and even assumes a metallic appearance; that of *cobalt* becomes dark; that of *zinc*, of a dirty white; that of *arsenic*, in the same acid, yellow mixed with red and white, orpiment and realgar being formed.

If oil of vitriol, whose specific gravity is 1,863, be dropped into hepatized water, it renders it slightly turbid; but, if the volatile vitriolic acid be dropped into it, a bluish white and much denser cloud is formed in the water.

Strong nitrous acid, whether phlogisticated or not, causes a copious white precipitation; but dilute nitrous acid produces no change. Green nitrous acid, whose specific gravity was 1,328, immediately precipitated sulphur from it.

Strong marine acid produced a slight cloud; but neither distilled vinegar nor acid of sugar had any effect.

It is said by Mr. BERGMAN, that hepatized water in a well closed vessel effects a solution of iron in a few days; but this experiment, on repeated trials, did not succeed with me: nor could I dissolve any other metal in this water; the sulphur indeed unites to many of them, but forms an insoluble mass;

so that, I presume, metallic substances can never be found in hepatized mineral waters.

SECTION VI.

Of the Properties of Alkaline Liquors impregnated with Hepatic Air.

I have already mentioned the proportion of air they are able to take up. Colourless fixed alkaline liquors receive a brownish tinge from this air. The residuum they leave is of the same nature as the part they absorb.

A caustic fixed alkaline liquor, saturated with this air, precipitates *barytes* from the acetous acid, of a yellowish white colour. It also decomposes other earthy solutions, and the colour of the precipitates varies according to their purity, and perhaps this test might be so far improved as to supply the place of the Prussian alkali.

It precipitates the solution of vitriol of *iron*, and also marine salt of iron, black; but this latter generally whitens by agitation. That which I used was very saturate.

The solutions of *silver* and *lead* are also precipitated black with some mixture of white; that of *gold* is also blackened; but that of *platina* becomes brown.

Solutions of *copper* let fall a reddish black or brown precipitate.

Sublimate corrosive by this test discovers a precipitate partly white and black, and partly orange and greenish.

In the nitrous solution of *arsenic* it forms a yellow and orange; and in that of *regulus of antimony*, in aqua regia, an orange precipitate mixed with black.

Nitrous

Nitrous solution of *zinc*, thus treated, shews a dirty white; that of *bismuth* a brown mixed with white; and that of *cobalt* a brown and black precipitate.

As *Prussian alkali* always contains some iron, it gives a purple precipitate with this test, which precipitate is easily dissolved.

It turns tincture of raddishes, which is my test for alkalies, green.

The action of liver of sulphur on metallic substances in the *dry way* is described by many authors, and particularly in an excellent Dissertation by M. ENGESTROM; but its action in the *moist way* has not been mentioned, as far as I recollect, by any. Hence I tried its effect on a few grains of iron, copper, lead, tin, zinc, bismuth, regulus of antimony, and of arsenic. Putting each into a bottle, containing about three half ounces of liquid liver of sulphur, so far diluted that its colour was yellow; in about fifteen days I found they all, except the zinc and tin, had attracted sulphur from the fixed alkali. Iron, arsenic, and regulus of antimony and lead, were most altered; copper next, and bismuth least: but the liquors held none of the metals in solution; that which contained iron became green; on adding an acid sulphur was precipitated; if it held iron it could not at that period be detected.

Water saturated with the condensed residuum of alkaline and hepatic air, that is, with the purest volatile liver of sulphur, does not precipitate marine *selenite*, though it forms a slight brown and white cloud in that of marine *baro-selenite*.

It produces a black precipitate in the solution of vitriol of *iron*, and a black and white in that of marine salt of iron; but by agitation this last becomes wholly white.

It

It precipitates both vitriol of copper, and the nitrous salt of copper, red and brown.

Tin in aqua regia gives a yellowish precipitate; *gold* a dilute yellow and reddish brown; *platina* a flesh-coloured precipitate; and *regulus of antimony* a yellowish red.

Silver is precipitated black; and so is *lead* both from the nitrous and acetous acids.

Sublimate corrosive appeared for an instant red; but soon after its precipitate appeared partly black and partly white.

The nitrous solution of *bismuth* affords also a precipitate, partly black, partly white, and partly reddish brown, and of a metallic appearance; that of *cobalt* is also black or deep brown.

Arsenical solutions give yellow precipitates more or less red; but those of *zinc* only a dirty white.

All these colours vary in some degree, according as the liquors are more or less saturated previous to and after their mixture, and the time they have stood together.

SECTION VII.

Of the Constitution of Hepatic Air.

From an attentive consideration of the above experiments, which I purposely disengaged from all theory, it is difficult to conclude, that hepatic air consists of any thing else than sulphur itself, kept in an ærial state by the matter of heat. Every attempt to extract inflammable air from hepatic air, when drawn from materials that previously contained nothing inflammable, namely, from alkaline or calcareous hepars,

proved abortive; on the contrary, when the materials could previously supply inflammable air, as when martial carbonaceous and saccharine compounds were employed, inflammable air, in ever so small a proportion, was detected: nor could hepatic air be procured from the direct union of inflammable air and sulphur, as we have seen.

Some have imagined, that this air consists of liver of sulphur itself volatilized, and consequently that an alkali enters into its composition; but many weighty reasons oppose this supposition. In the first place this air is evidently, though weakly acid, since it reddens litmus, and precipitates acetous baro-selenite. 2dly, It may be extracted from materials that either contain no alkali at all, or next to none, as iron, sugar, oil, charcoal: and, lastly, it is not decomposed by marine or fixed air, by which, nevertheless, liver of sulphur is decomposable.

I formerly thought that sulphur was held in solution in hepatic air, either by vitriolic or marine air; yet though both of them may hold sulphur in solution, as we have seen, still neither of them is essential to the constitution of hepatic air as such, since it is producible from materials that contain neither of these acids; and, from whatever subject it is obtained, it exhibits the characters of one and the same acid, namely, the *vitriolic exceedingly weakened*; and such an acid we may suppose sulphur itself to be.

In effect, sulphur, even in its concrete state, affords many characters of acidity. It unites with alkalies, calcareous and ponderous earths, and most metals, as a weak acid might: and except a manifest solubility in water (a property which some other concrete acids also possess in a very weak degree) it exhibits every character of acidity. But its acidity is the weakest possible, since it decomposes only acetous, and not marine baro-selenite,

selenite, and is separable from alkalies and earths by all other acids.

That the matter of heat enters into the composition of this air, is evident from the experiments of M. SCHEELÉ, who paid particular attention to that object. He found, that acids excite much less sensible heat in uniting with *liver of sulphur*, whether alkaline or calcareous, than while uniting with a proportion of caustic fixed alkali or lime equal to that which enters into the composition of those *livers*; whence he justly infers, that the *difference* enters into the composition of the hepatic air produced. I have proved the same thing another way: for, instead of decomposing an *alkaline* hepar by marine acid, I tried to decompose it by a saturate solution both of marine selenite and marine Epsom. The decomposition indeed took place, but no hepatic air was produced; for the acid having given out its specific heat on uniting to the earths, had none to lose or communicate on uniting to the alkali, and consequently the sulphur receiving none could not be thrown into an aerial state.

It is remarkable, that bodies capable of an aerial form receive the latent heat necessary for that form, much more readily from a body that parts with its specific heat than by the mere application of sensible heat. Thus aerated barytes cannot be decomposed by mere heat, as Dr. WITHERING has shewn, though its air is easily separated from it by an acid; and in the same manner antimony cannot be desulphurated even by vitrefaction, though it may by acids: so liver of sulphur will not give hepatic air by mere heat, though it will by the intervention of an acid, even the weakest. The reason of which seems to be this: the matter of heat has no particular affinity with any substance, as is evident from its passing

indifferently from any hot body to a colder, of whatever sort or kind the bodies may be; but it is determined to unite with this or that body in a latent state, in greater or lesser quantity, in proportion to the greater or lesser *capacity* of these bodies to receive it. Now acids, by uniting to the alkaline basis of liver of sulphur, expel the sulphur, and give it their heat, at the *instant* the sulphur, by its separation, has the capacity to receive it; whereas sensible external heat, acting alike on both the constituent parts of liver of sulphur, separates neither; or if it separates them, yet, by its *successive* action, it throws one of them into a *vaporous* state first, and bodies that *first* acquire this state can never after acquire an aërial state by any *subsequent* accession of heat.

The vitriolic and nitrous acids are less adapted to the production of hepatic air than the marine acid, though they contain more specific heat than the mere acid part of the marine acid: the most probable reason of which is, because they have a stronger attraction to sulphur itself, and so detain it.

Hepatic air is much disposed to give out its latent heat, particularly when in contact with substances to which it has any affinity; thus it is condensed in water in a few days; it is also condensed by long exposure to fresh surfaces of mercury or silver or other metals, particularly if they are moist. M. BERGMAN found it in great measure condensed into sulphur, when inclosed alone in a bottle *. In this case it probably contained an excess of sulphur; for hot hepatic air is capable of keeping a farther quantity of sulphur in solution, and depositing it when cold, as I have frequently observed.

* See a note in the second volume of M. MORVEAU'S translation of the second volume of BERGMAN'S Works, p. 341.

The precipitation of metallic substances by this air is owing partly to the union and phlogification of the acids by this air, and partly to its union with the metals themselves, for it evidently unites in most cases to both.

As alkalies and sulphur are known to have an affinity to each other, we easily understand why hepatic and alkaline airs are condensed when mixed with each other; nor is there any difficulty in conceiving why hepatic air is not condensed by common, dephlogificated, inflammable, or phlogificated airs, or remarkably by marine air; but it seems very extraordinary, that hepatic air and vitriolic air should be condensed, and in great measure converted into sulphur by their mutual action on each other, particularly as they both seem nearly of the same species, or at least nearly allied to each other. The attraction of two bodies, thus circumstanced, is certainly very extraordinary; yet that their union proceeds from attraction seems pretty evident, for concentrated vitriolic acid, and particularly volatile vitriolic acid, precipitates sulphur copiously from hepatified water. Volatile vitriolic acid frequently holds some sulphur in solution, as appears from the experiments of Dr. PRIESTLEY and M. BERTHOLLET; and hence it deposits some when it loses its aerial form, or by mere length of time; but the whole of this condensed air is not turned into sulphur, for the water that washed the precipitated sulphur took up a quantity of volatile acid and fixed air, as has been shewn.

The condensation of hepatic air by nitrous air seems owing to the same cause; for when the nitrous air was in great degree deprived of superfluous acid, the condensation of the hepatic was much slower; and that which after all took place seems to have been effected by the decomposition of the nitrous air, and the consequent extrication of an acid.

The

The decompositions effected by fixed and volatile livers of sulphur obviously proceed in most cases from a double affinity.

S E C T I O N VIII.

Of Phosphoric Hepatic Air.

As phosphorus, in respect to its constituent parts, bears a strong resemblance to sulphur, I was naturally led to examine its phenomena when placed in the same circumstances: I therefore gently heated about 10 or 12 grains of phosphorus, mixed with about half an ounce of caustic fixed alkaline solution, in a very small phial, furnished with a bent tube, and received the air over mercury. Upon the first application of heat two small explosions took place, attended with a yellow flame and white smoke, which penetrated through the mercury into the receiver; these were followed by an equable production of air. At last the phosphorus began to swell and froth, and fearing the rupture of the phial, I stopped the tube to prevent the access of atmospheric air, and removed the phial to a water tub, intending to throw it in; but in the mean while the phial burst with a loud explosion, by reason of an obstruction in the tube, and a fierce flame immediately issued from it. However I obtained about 8 cubic inches of air.

This air was diminished very slightly, by agitation with an equal bulk of water, and then became cloudy like white smoke, but soon after recovered its transparency. Upon turning up the mouth of the tube to examine the water, the unabsorbed air instantly took fire, and burned with a yellow flame without exploding, leaving a reddish deposit on the sides of the tube.

Water

Water impregnated with phosphoric air, and over which this air had burned, slightly reddened tincture of litmus :

Did not affect Prussian alkali :

Had no effect on the nitrous solutions of *copper* or *lead*, *zinc*, or *cobalt*, nor on marine solution of *iron* or *tin*, or of tin in aqua regia, nor on the vitriolic solutions of *iron*, *copper*, *tin*, *lead*, *zinc*, *regulus of antimony*, *arsenic*, or *manganese* ; nor on the marine solutions of *iron*, *copper*, *lead*, *zinc*, *cobalt*, *arsenic*, or *manganese*.

But it precipitated the nitrous solution of *silver* black, and vitriol of silver brown ; also nitrous solution of *mercury* made without heat brown and black ; but vitriol of mercury first became reddish, and afterwards white ; and sublimate corrosive yellow and red mixed with white.

Gold dissolved in aqua regia is precipitated purplish black, and from the vitriolic acid brownish red and black ; but *regulus of antimony* in aqua regia is precipitated white by this phosphorated water.

The nitrous solution of *bismuth* shewed first a white, and presently after a brown precipitate. Vitriol of bismuth and marine salt of bismuth were also precipitated brown ; this latter re-dissolved by agitation.

The nitrous solution of *arsenic* also became brown, but re-dissolved by agitation.

I afterwards impregnated some water with this air, without suffering the air to burn over it : it scarcely affected litmus, did not precipitate lime-water ; but it caused a black precipitate in solution of *silver*, a white precipitate of *regulus of antimony* in *AR*, and a whitish yellow in that of *sublimate corrosive*.

To a measure of this air I let up a measure of water, and through this some small bubbles of *common air* ; every bubble
flamed

flamed and produced a white smoke until about half as much common air was introduced as there was originally of phosphoric; and yet the original bulk did not appear increased; the flame each time produced a small commotion, and a smoke descended after inflammation into the water: when flame ceased to be produced, smoke still followed the introduction of more common air. Bubbles of phosphoric air, escaping through mercury into the atmosphere, flame, crackle, and smell, exactly like the electric spark*.

To a measure of phosphoric air I let up a half measure of *nitrous air*: a white smoke appeared, with an exceeding slight diminution, and the transparency was soon restored, a slight scum being deposited on the sides of the jar. Another half measure of nitrous air produced no smoke or diminution; but on adding water, and agitating the air in it, much more of it was absorbed. Upon turning up the jar the nitrous air first escaped in the form of a red vapour, and this was followed by a whitish smoke. The water had a phosphoric smell, and precipitated the solution of silver brown. In this experiment the acid of the nitrous air seems to have acted the same part that it does in hepatic air.

Phosphoric air was scarce at all diminished by the addition of an equal measure of *alkaline air*; and water being put up to these, took up in appearance little else than alkaline air, yet on turning up the mouth of the jar, the residuary air smoked without flaming.

* A few months after I made these experiments on phosphoric air, the tenth volume of the *Mémoires des Savans Etrangers* was published; and in this I found, that the spontaneous inflammation of this air was known to M. GINGEMBRE in the year 1783. His experiments are now published in ROZIER's Journal for October, 1785.

The water, thus impregnated, had exactly the smell of onions. It turned tincture of radishes green.

It precipitated solution of *silver* black; and that of *copper* in the nitrous acid brown; but this precipitate was re-dissolved by agitation, and the liquor became green. *Sublimate corrosive* was precipitated yellow mixed with black.

Iron was precipitated white, both from the vitriolic and marine acids; but a pale yellow solution of it in the nitrous acid was not affected; and a red solution of it in the same acid was only congrumated.

Regulus of antimony in aqua regia gave a white, *cobalt* in nitrous acid a very flight reddish, and *bismuth* in the same acid a brown precipitate.

But neither the nitrous solution of *lead* or *zinc*, nor that of *tin* in marine acid or aqua regia, nor that of *regulus of antimony* in aqua regia, were any way affected.

Fixed air, mixed with an equal proportion of phosphoric air, produced a white smoke, some diminution, and a yellow deposit. On agitating the mixture in water, the fixed air was taken up all to one-tenth. The residuum smoked, but did not inflame spontaneously.

To a small portion of phosphoric air I introduced some *precipitate per se*. It soon grew black, and a white smoke appeared. In two days the precipitate remained solid, yet acquired a shining pale white colour, like that of steel: the air lost its spontaneous inflammability; but I am not certain that this want of inflammability did not proceed from some other cause; for two days after I made this air, I found a quantity of it, which had rested all night on water, had deposited a yellow scum on the sides of the jar, and lost its spontaneous inflammability next morning. The temperature of the air was

then 53° ; and when it inflamed before, the temperature was 68° .

From these few experiments, which the small quantity of air I then obtained did not suffer me to repeat, I think we may conclude, that phosphoric air is nothing else but phosphorus itself in an aërial state, and differs from sulphur in this, among other points, that it requires much less latent heat to throw it into an aërial form, and hence may be disengaged from fixed alkalies, without the assistance of an acid.

